LARVAL CHARACTERS OF GENUS DIXA

By Frank K. Smith

This study of the larval characters of the genus Dixa was made at Cornell University during 1925 and 1926. Detailed observations were made upon the larva of *D. cornuta* Joh., and later observations of the larvæ of nine other species were made for the purpose of finding characters by which the larvæ of the different species studied could be differentiated. For many of the specimens and many helpful suggestions the writer is very grateful to Dr. O. A. Johannsen.

Description of the Larva of D. cornuta Joh.

The larva of *D. cornuta* Joh. is subcylindrical and, in the instar preceding pupation, about six millimeters in length. It is grayish except the head, which is amber with a fuscous ring around the caudal margin, the spiracular and the lateral plates, the tergum of the tenth abdominal segment, and the entire eleventh segment, which may vary from brownish-yellow to light amber. The body, with the exception of the head and the spiracular and the lateral plates, is pubescent, although the short hairs covering the body are much less dense ventrally than dorsally. (Plate IX, Fig. I.)

A dorsal view of the head presents an outline of two fairly regularly curved sides and a concavity caudad into which the conjunctiva joining the head to the prothorax is attached. At the anterior limits of the curved sides are the antennæ. Caudad of these are the eyes, which may be seen either in the ventral or dorsal view because of their lateral location. From the base of the antennæ the cephalo-dorsal margin of the skull gradually tapers to a point in the region between the mouth-brushes. For about the proximal three-fourths of this distance there is a slight concavity on each side. The remaining distal portion consists of a triangular appendage, fastened to the sides of which are

the mouth-brushes. From underneath this region, along each side, the more ventrally located maxillary palpus, maxilla, and mandible project.

On the dorsal surface of the head capsule are a few constant setæ. A pair is located, one on either side, midway between the base of the antenna and the caudo-lateral margin of the capsule; a second pair, one each near the base of each antenna; a third, one each mesad a short distance from each member of the preceding pair; a fourth, one each at each distal angle of the prolonged dorso-cephalic portion of the skull and just caudad of the respective caudal angle of the labrum; a fifth, one each slightly mesad of each member of the preceding pair. (Plate IX, Fig. I, also Plate X, Fig. XL.) In the figures the pairs are designated respectively *f, g,* and *h* in Plate IX, Fig. I and *j* and *i* in Plate X, Fig. XL. Besides these setæ, others seen from the dorsal view will be discussed in connection with the appendages upon which they occur.

The triangular labrum which bears the mouth-brushes is represented by 2 in Plate X, Fig. XL. Each mouth-brush (Plate X, Fig. XL, 1) consists of a cluster of very densely arranged long coarse hairs. The distal ends of these taken collectively present much the appearance of the sweeping surface of a broom. Near the cephalic end of the base of each mouth-brush and to either side of the dorsal surface of the labrum there arises a long bluntly ending seta (Plate X, Fig. XL, m) which extends forward to the distal ends of the mouth-brushes. Near the caudal end of the base of each mouth-brush and on the dorsal surface of the labrum is a short clavate seta (Plate X, Fig. XL, l) about equal in length to the basal width of the brush. Mesad a short distance from each of these clavate setæ is a relatively long seta of the usual type. (Plate X, Fig. XL, k.) Each antenna has only a single segment with a relatively broad base. It extends forward a distance approximately equal to the distal limits of the mouth-brushes and is heavily spined upon the distal half. As seen under high magnification the distal end is slightly rounded, though blunt at the extreme tip which is fringed with short spines. There is a small seta on the outer margin one-

fourth of the distance from the distal end and a brush of hair on the inner margin covering approximately the second fourth of the antenna from the distal end. (Plate IX, Fig. III.)

The general outline of the ventral surface of the head is about as in the dorsal aspect with the exception that the cephalic margin, which is not greatly extended forward, presents three rounded triangular projections—a mesal one and one on each side. (Plate IX, Fig. III.) From beneath the cephalic margin —viewing the specimen ventrally—the mouth parts extend. From beneath the mesal projection the "hypopharynx" extends, on each side of which is a maxilla. From underneath the inner margin of each maxilla a row of long mandibular hairs or cilia extend mesally and curve toward the dorsal extension of the skull. Finally, from underneath all these parts—when viewed ventrally—the labrum and long mouth-brushes extend cephalad.

There are a few setæ characteristic of the ventral region of the head, exclusive of its appendages. (Plate IX, Figs. II and III.) The best developed pair is located one on each side of the mesal line and in the occipital region at the junction of the head with the conjunctiva (Plate IX, Fig. III, n); a second pair, one on either side about two-thirds of the distance caudad between the base of the antenna and the caudal margin of the head. (Plate IX, Fig. III, o); and a third, one each at the apex of each of the lateral projections of the cephalic margin of the ventral surface of the head capsule. (Plate IX, Fig. III, u.) A group of three is arranged in the form of a triangle slightly ventrad of the base of each antenna and of these the one caudad is much smaller. (Plate IX, Fig. III, s.) Besides these setæ of the ordinary type there are three pairs of clusters of setæ, each cluster like a bundle of fagots and arising from a common puncture. A pair of such clusters is located, one at each end of the base of the mesal projection of the ventro-cephalic margin of the head capsule (Plate IX, Fig. III, t); and a second pair, one each near the middle of the inner side of each lateral projection of the ventro-cephalic margin of the capsule. (Plate IX, Fig. III, t′.) The structures upon which a third pair of such clusters is located has not been definitely determined. It seems that one

of this pair is located in each of the lateral fossæ between the dorsal and ventral cephalic extensions of the skull—the fossæ in which the bases of the mandibles and the maxillæ have their articulation. (Plate IX, Fig. III, t″.)

The eyes and the antennæ, because of their lateral position, have the same relative location in the ventral as in the dorsal aspect.

Some mouth parts are much better observed from the ventral than from the dorsal aspect. The uppermost of these (viewed ventrally) are the maxillæ (Plate IX, Fig. III and Plate X, Fig. I.) They are thin, colorless, membranous flaps, only slightly thickened towards the outer margin, and fitted distally with numerous small hairs recurved mesally and at their inner bases with numerous short straight hairs. From the outer margin of the base of each arises a two-jointed palpus of which the basal segment is not more than one-fourth as long as the distal one and lacks spines, but bears a short seta on the outer distal surface. The second segment enlarges slightly and gradually towards the tip and tends to become rounded at the distal end, although, as seen under high magnification, the extreme tip is truncate and fringed with short spines. The distal four-fifths of the second segment is spiny, but the spines are stronger and more obvious upon the distal half.

Dorsad of the maxillæ and closely united to them at their bases are the mandibles. (Plate X, Fig. IV and Plate IX, Fig. III.) The mandible is greatly thickened towards its outer margin and tapers distally to a point. Due to the gradual increase in width toward the outer portion of the mandible its base is triangular in outline with the apex pointing mesally. Only a small portion of the mandible near its inner base is strongly chitinized and typically mandibular in form, having two well-defined apical teeth, (Plate X, Fig. IV, 1). The apex of the more membranous portion is fitted with a small chitinized tooth. Along the strongly curved outer surface, a short distance from the apex, is a depression from which arises a lanceolate spine or claw, equal to or greater than half the length of the mandible. (Plate X, Fig. IV, 2.) On the dorsal surface of the

membranous portion, a short distance from and parallel to its inner margin is a row of long hairs or cilia extending dorsally and curving mesally so as to meet similar structures of the opposing mandible. (Plate X, Fig. IV, 3.) About the middle of the convex outer surface are two setæ, a long one (Plate X, Fig. IV, v), slightly ventrad, and a short one (Plate X, Fig. IV. z), slightly dorsad.

From the ventral wall of the cephalic end of the pharynx arises the so-called "hypopharynx." (Plate IX, Fig. III, 3.) Its base is strengthened by a strong triangular chitinous loop which serves perhaps as a base for its attachment to the wall of the pharynx. This chitinous base may be seen, in the cleared specimen, through the mesal projection of the ventro-cephalic margin of the head capsule. The "hypopharynx" runs cephalad and curves dorsad and its distal cephalic margin is fringed with a number of short blunt spines—arranged superficially as a rake.

The ventral surface of the dorso-cephalic prolongation of the head gradually slopes in a caudo-ventral direction from the mouth-brushes to the dorsal wall of the pharynx. (Plate IX, Fig. I and Plate X, Fig. XL.)

THE THORAX

The head is connected to the thorax by means of a relatively long conjunctiva. (Plate IX, Fig. II.) The setæ located on the ventral side at the junction of this conjunctiva with the occipital region of the skull have already been described.

The prothorax is shorter than the mesothorax. In width it is equal to the abdominal segments. (Plate IX, Fig. I.) As seen in the dorsal aspect four setæ are observed in a line across the middle of the segment, two of which are on each side of the mid-dorsal line. These two pairs are so small as to require fairly strong magnification in order to observe them upon the pubescent surface. Each of these pairs is perhaps homologous to two of a group of three small setæ occurring in relatively similar position upon each of the succeeding thoracic segments and each of the abdominal segments from one to eight, inclusive. What has become of the third seta is a matter of conjecture.

However, in the arrangement of the groups of three in the other segments mentioned it is noticed that the inner member of each group of three has a tendency to stand more or less apart from the other two. The other two members are relatively close together. The general arrangement of these groups of three and the fact that the two which occupy a similar position upon the prothorax stand relatively well apart indicates that one of the outer two members of the group of three is apparently absent in this segment. It is possible that the dorsal one of the two short setæ near the long lateral seta, shown in the ventral view of the cephalic margin, is a member of this group of three which has migrated forward. (Plate IX, Fig. I and Fig. II.) However, this sort of condition implies a degree of separation of the outer two of the triad which is not approached in any of the other segments.

The ventral surface of the prothorax has, as already alluded to, a long seta on each side near the cephalic margin with a small seta on each side of it and close to its base. (Plate IX, Fig. II.) There is also another on each side of the mid-ventral line near the cephalic margin. Between each of these and the long lateral seta of its respective side is a group of four, extremely close together at their bases. Still laterad between each group of four and the long lateral of the respective side is another long seta. So the order of long setæ along the cephalic margin of the prothorax is 1–1–4–1–1–4–1–1. The long setæ of the cephalic margin, fourteen in number, extend well beyond the distal ends of the mouth-brushes when the former are pressed flatly against the body. In the natural position these setæ extend cephalo-ventrad.

The mesothorax widens regularly towards its caudal margin. This widening is especially noticeable as the larva approaches the pupation period. On the dorsal surface to either side of the mid-dorsal line is a group of three small setæ. (Plate IX, Fig. I.) Laterad and slightly cephalad of each of these groups is a seta of intermediate length. Like the well-developed setæ of the prothorax these also extend cephalo-ventrad. On the ventral surface in a line extending across the mesothorax about

one-third of the distance caudad of the cephalic margin are four setæ separated by rather uniform intervals—two on each side of the mid-ventral line. (Plate IX, Fig. II.) Slightly caudad of a point midway between each of these pairs is a group of four setæ, arising from as many punctures, extremely close together and spreading apart in a somewhat stellate manner.

The metathorax is much shorter than the mesothorax and gradually widens from its caudal towards its cephalic margin. Viewed laterally the distension of the meso- and metathoracic segments is not so pronounced. The arrangement of the setæ on the dorsal surface of the metathorax is essentially similar to that of the preceding segment. (Plate IX, Fig. I.) Likewise there is a similarity on its ventral surface to that of the preceding segment, with the exception that instead of four setæ stellately arranged on each side there is a pair of setæ which arise from punctures that are very close together. (Plate IX, Fig. II).

THE ABDOMEN

The first and second abdominal segments are so alike in structure and arrangement of setæ that they will be considered together. On the ventral surface about one-third of the distance caudad of the cephalic margin is a pair of prolegs, one on each side of the mid-ventral line. They are fleshy lobes equipped at the distal ends with rows of densely fitting claws, which curve toward the cephalic surface of the prolegs. (Plate IX, Fig. II.) The triads of setæ on the dorsal surface are in their typical position and arrangement as shown in the figure. (Plate IX, Fig. I.) Laterad of each of these triads is a pair of longer setæ located in a transverse line with reference to each other. Homologues of these pairs are present also on the abdominal segments from the third to the seventh inclusive. They possibly occur also on the eighth, but the homologies of this segment because of its specialization are not so evident. On the ventral surface of the second abdominal segment there is a transverse row of four setæ in a position similar to the transverse rows of four on the meso- and metathoracic segments. On the second

abdominal segment the setæ are rather uniformly spaced. A pair is between the bases of the prolegs—one on each side of the mid-ventral line and a seta is laterad of each proleg. On the corresponding surface of the first abdominal segment we have a condition homologous to that of the second except instead of one there is a pair of setæ laterad of each proleg. However, the constancy of these extra setæ may rightly be doubted inasmuch as there were specimens in which they could not be definitely located. In a few they were quite distinct. On each of these segments there is a pair of setæ laterad and slightly caudad of the outer members of the transverse rows of four. These pairs perhaps have homologues in the pairs caudad of the outer setæ of the ventral transverse row on the metathorax.

While mention has been made of the homologues of setæ, we might consider a few which have no obvious homologues. The stellate group of four on the ventral surface of the mesothorax is such. These may be composed of two setæ homologous to the ventro-lateral pairs on the metathorax and the abdominal segments plus two other setæ independently developed. (Plate IX, Fig. II, c and c + 2.) In like manner the group of four long setæ on the ventral surface of the prothorax may consist of two homologous to the lateral pairs mentioned above plus two independently derived. Furthermore, if such is the correct interpretation of the homology of this group, it has not remained caudad of the transverse ventral row of four but has migrated to the cephalic margin of the segment. (Plate IX, Fig. II, c + 2.) If this group of four on the prothorax may be interpreted in this manner, it is much more evident that the four long setæ of the prothorax which arise separately—not clustered—on the ventro-cephalic margin should be considered as homologues of the transverse rows of four on the segments, which have been discussed. The long laterals on the dorsal surfaces of the second and third thoracic segments and slightly ventrad on the first may be considered as homologues. (Plate IX, Fig. I, b and b –1; Fig. II b.) If this point of view is correct, perhaps we should consider that the lateral pairs on the abdominal segments, one to seven, represent a prototypic condition; and that in the place of the single

lateral seta on each of these thoracic segments there was formerly a pair, as occurs at present upon these abdominal segments. Indeed, it may be that the short seta on each side of the ventral surface of the prothorax represents one of this pair of homologues, while the short seta dorsal of the long lateral of the same segment represents one of the group of three of which there are homologues on the dorsal surfaces of other segments, thoracic and abdominal, to and including the eighth abdominal. (Plate IX, Fig. 1, a, and Fig. II, b.) There is, nevertheless, some doubt as to whether the two short setæ of the cephalic margin of the prothorax are constant. In some specimens they were quite distinct, while in others they had either been broken off or were lacking. These remarks will give some idea of the probable homology of these more or less problematical setæ.

The third and fourth abdominal segments constitute a region of the body in which flexing occurs during locomotion. There are neither prolegs, locomotory plates, nor long setæ upon these segments. On the ventral side we have three pairs of setæ which can be rather readily homologized with three pairs upon the preceding segment by reference to the figure. On the dorsal side we have setation very homologous also to that of the preceding segment. (Plate IX, Figs. I and II.)

The fifth, sixth, and seventh abdominal segments are of quite homologous setation and each is fitted with a pair of ventral spinous plates used in locomotion. The arrangement of the setæ upon the dorsal surfaces is so similar to that upon the preceding segment that no comments are necessary in this particular. (Plate IX, Fig. I.) On the ventral surfaces the two pairs of mesal setæ are separated rather widely by the paired plates of spines—otherwise these setæ of the ventral surfaces are arranged as in the preceding segment. The inner pairs of setæ increase in length from the fifth to the seventh segments inclusive—the innermost member of each inner pair upon the seventh extends well beyond the tips of the ciliated lateral plates. On these segments—five to seven—the innermost of each outer pair of setæ is the longer. In these segments and the others the ventral setæ are longer than the dorsal, and those nearest the

mid-ventral line are longer than those more lateral. The spiny plates of each segment consist of from five to eight spines—each varying in length from the very short lateral to longer ones at the center. The plates of each pair are separated by a chitinized area shaped as in the figure. (Plate IX, Fig. II.)

THE CAUDAL REGION

The caudal region consists of four segments of very complex nature.

The eighth abdominal segment bears on each side of the mid-dorsal line and upon its caudal margin an ear-like flap which extends laterally. These will, hereafter, be referred to as the spiracular plates. At the proximal end of each plate and on its cephalic margin is a concavity in which the spiracle is located. At the distal end and slightly cephalad on the margin is a very slight indentation from which a short bar or line, apparently of chitin, extends meso-caudad for a short distance across the plate. The dorsal surface of each plate is concave and the margin is fringed with a thick row of hairs or cilia which are somewhat greater in length toward the disto-caudal angle. The spiracles are circular and in the preserved specimen, at least, have a few short lines radiating from the center toward the circumference. (Plate X, Fig. XXIX, 3.) These may represent a closing device. Between the spiracular plates and the mesal line is a small, chordate, chitinized area. Cephalo-laterad of this area on each side is a group of three branched, scale-like or palmate setæ which have a similar location and arrangement with reference to the segment and each other as do the groups of three small setæ on the dorsal surfaces of the more cephalic segments. Because of these conditions these groups of palmate setæ are believed to be the homologues of these setæ arranged in triads upon the segments more cephalad. (Plate X, Fig. XVIII.) The other setæ of this segment (number eight) and their location are as in the preceding segment and readily homologized, with the exception that the innermost of the inner pair on the ventral surface is represented by two setæ in this segment. There is thus an extra seta so that the inner pair of

other segments is represented in this segment by three setæ, which extend to or beyond the point of the last segment. (Plate IX, Fig. II, d + 1.)

The ninth segment is still more specialized than the eighth. Viewed from the dorsal aspect two more or less boat-shaped plates are attached one on each side, and extend caudally in the dorsal plane of the body. These structures have been referred to by Doctor Dyar as the ciliated respiratory tubes, but we shall refer to them as lateral plates, a term used by Tonnoir. The upper surfaces of the structures are concave and the entire margin of each is fringed by a dense row of long stiff plumose hairs or cilia. (Plate X, Fig. XXII.) The hairs toward the distal ends of these plates show a considerable shortening. From underneath the fringe of hair a chitinized point extends caudad. On the dorsal surface of each plate and near the basal inner margin is a knob or tubercle bearing a long seta which extends cephalo-dorsad. (Plate IX, Fig. I.) On the ventral side of each near the outer caudal margin is a smaller seta which points caudo-ventrad. (Plate IX, Fig. II.) Between the bases of these plates is an area of the tergum of the segment which is strongly chitinized and thus serves perhaps to give rigidity and support to the plates. The row of hairs on the outer margin of each plate is continued cephalad from the base to the cephalic margin of the segment to a point just caudad of the base of the spiracular plates. In this manner the hairs of the lateral plates are connected in a continuous row with those of the spiracular plates. The more obvious structures of the ventral side are two ridge-like structures—one on each side. (Plate IX, Fig. II.) Each ridge is fitted with a row of scale-like spines of which most are triradiate. At the mesal end of the ridge is a triradiate spine much larger than the others. This row of spines or scales has been termed the pecten. Between this pecten and the cephalic margin of the segment is a more strongly chitinized area extending dorso-laterad to the outer basal margin of the plate. Cephalad of the pecten a short distance is a minute seta.

The tenth abdominal segment is conical with the apex of the cone directed caudally. The dorsal surface is chitinized more

than the ventral and lacks setæ. On the extreme caudal end of this segment the chitinized area of the dorsal surface extends latero-ventrad and surrounds the ventral portion of that region. From the cephalic margin of this chitinized ventral area about twelve to fifteen spines of more or less branched nature extend caudad for a distance equal to the length of the area. (Plate X, Fig. III, 1.) Between the base of this chitinized area and the more membranous portion is the anus. Pressure in this region upon an alcoholic specimen frequently forces out four anal gills which in the living specimen are retractile. (Plate X, Fig. VI, 1.) The spines which have been mentioned apparently serve as guards for the gill chamber. About midway along the lateral region of this membranous ventral portion on each side is a triangular chitinous plate with an apex pointing cephalad. From this plate three setæ arise and extend well to the caudal tip of the body. (Plate IX, Fig. II.) If these have homologues among the other setæ of the larvæ they may be considered homologous to the three long setæ on each side of the ventral surface of the eighth segment. There is not much evidence to bear out such a conjecture other than the presence of two of the three on the eighth segment upon a chitinized plate, the similar location of the three upon this ninth segment, and the fact that the extra strain put upon this third during swimming by the force of the water, due to its more caudal position, has perhaps led to its inclusion upon the chitinized base with the other two. This last development is a further step in supporting the bases of the long setæ. Such a tendency was observed in the basal supports of the long setæ in the ventral surface of the eighth segment.

The eleventh is quite simple, though of a very different form as compared with the other segments. It is clavate with a small spine-like structure, which is more or less chitinized toward the tip, located at its dorso-caudal extremity. The ventral portion of the caudal end of this segment has a rather rounded outline, as compared with the dorsal portion of this end. The spine-like structure at the caudal end of this segment is not a spine in the sense that its chitin is continuous with the segment at the point

of attachment, for it may be easily and smoothly broken off. Near the distal end of this segment and on the ventral surface to each side of the mesal line arise two very long setæ. A similar seta arises slightly dorsad of each of these two on each side of the distal end. Because of the number being equal, the location similar, and the degree of development about equal to the ventral setæ of the preceding segment, these caudal setæ are thought homologous to them. (Plate IX, Figs. I and II.)

In the study of this larva a few small setæ were found from time to time for which a constancy of occurrence could not be determined. These have not been included in the figures showing setation. The lettering of the setæ represented in the plates indicates the probable homologues by giving the same letter to homologous setæ of the different segments.

COMPARATIVE STUDY OF LARVAL CHARACTERS

The preceding description of the larvæ of *Dixa cornuta* Joh. has a greater significance when the characters described are seen in comparison with those of the larvæ of other species. A study of nine species besides *D. cornuta* Joh. has been made. Two of them were unidentified larvæ, from California; *D. aliciæ* Joh., from the same state; four unidentified larvæ, from New York; *D. modesta* Joh. from New York; and *Dixa fusca* Loew, from Ithaca, New York. For materials necessary for the study of all these species except *D. cornuta* Joh. and *D. fusca* Loew, the writer is indebted to Dr. O. A. Johannsen. Each of these ten species, including *D. cornuta* Joh., shows characters which may be considered as specific.

The species examined may be divided into two groups, for each of which there are numbers of very definite characters. The structural differences marking each group off from the other are very definitely and closely correlated. The species within each group have fewer and less-marked characters by which they may be separated than do the groups.

The parallel columns on the following pages indicate the numerous and well-marked differences of the two groups. *Dixa*

cornuta Joh. may be considered as the type for one of the groups; *D. modesta* Joh. for the other group.

GROUP 1

1. No coronæ on abdominal segments 2–7 inclusive.
2. Long prothoracic setæ. (Plate IX, Fig. II.)
3. Locomotory plates relatively strong and long.
4. Long setæ on each side of last two pairs of locomotory plates.
5. Long ventral setæ on eighth abdominal segment. (Plate IX, Fig. II.)
6. Spiracular plates not distinctly ovoid. (Plate X, Fig. XXIX.)
7. Prespiracular scales palmate and much branched. (Plate X, Fig. XVIII.)
8. Scales or spines of pecten with multiple pointed projections. (Plate X, Figs. IX–XIV.)
9. An acute point at apex or distal end of lateral plate. (Plate IX, Figs. I and II.)
10. Three long setæ from a triangular chitinized plate extend ventro-caudad from each side of the eleventh abdominal segment. (Plate IX, Fig. II.)

GROUP 2

1. Such are present. (Plate X, Fig. XXXIV.)
2. Relatively short prothoracic setæ.
3. Such plates shorter and weaker.
4. Short setæ on each side of these plates. (Plate X, Fig. XXXV.)
5. Short ventral setæ on this segment. (Plate X, Fig. XXXV.)
6. Ovoid spiracular plates—rather convex on caudal as well as on the cephalic margin. (Plate X, Fig. XXX.)
7. Such scales not palmate, and more slightly branched. (Plate X, Fig. V.)
8. Such scales or spines simple. (Plate X, Figs. VII and VIII.)
9. No such point present. (Plate X, Figs. II, XXXVI, and XXXVII.)
10. All three of these setæ not well developed. Where specimens could be observed the better developed of the group were found to arise from the distal end of a line of chitin which extends meso-caudad from the margin of the chitinized dorsum of the segment. (Plate X, Fig. XLI.)

11. Caudal segment extends well beyond the apices of the lateral plates. (Plate IX, Fig. I.)	11. Caudal segment much shorter. (Plate X, Figs. XXXVII and XXXVII′. Also (Plate X, Fig. II.)
12. Hairs on caudal segment distinct. (Plate IX, Fig. I.)	12. Hairs on caudal segment slight or absent. (Plate X, Fig. II.)

To Group I belong *D. cornuta* Joh., *D. aliciæ* Joh., *D. fusca* Loew, species A, species B, and species E. The larva of the first has been described, and below the more important characters of the larvæ of the other species are noted.

D. aliciæ Larva. Antennæ are with well-developed setæ on outer margin about a third of the length from the distal end, a bunch of hairs on the inner surface of each near the distal end, and finer spines than in *D. cornuta* Joh. (Plate X, Fig. XXXIX.) Teeth of the chitinized area of the mandible are separated by a relatively wide gap, and the second tooth is more prominent than the corresponding tooth of *D. cornuta* Joh. (Plate X, Fig. XXI.) Ventral prothoracic setæ are in the order 1–1–1–4–1–1–4–1–1–1. Locomotory spines are slightly more developed than in *D. cornuta* Joh. The pecten scales commonly have two strong radiating spines and a few weaker ones. (Plate X, Fig. IX.) The caudal segment is shaped as that of *D. cornuta* Joh. This species is from California.

D. fusca Larva. The order of the ventral prothoracic setæ of this species is 1–1–1–4–1–1–4–1–1–1. The outer two of the group of three on the dorsal surface of the prothorax are not inconspicuous as in *D. cornuta* Joh. (Plate IX, Fig. I.) Each antenna is similar to that of *D. cornuta,* with a few coarse inner hairs, strong spines over distal half, and a small seta on outer margin a fourth of the distance from the distal end. (Plate X, Fig. XXXVIII.) Extra inner ventral setæ are not only on the eleventh abdominal segment as in *D. cornuta,* but also on the eighth, ninth and tenth abdominal segments. The last of the ventral plates is weaker than the preceding pairs. The pecten scales have eight or nine spines. (Plate X, Fig. XI.)

The dorsum of the head is fuscous; the lower part yellowish-brown. The species is from Ithaca, New York.

Species A Larva. Only one tooth is in the heavily chitinized portion of the mandible. (Plate X, Fig. XIX.) The antennæ are of the type figured for *D. cornuta,* i.e., each has a slightly developed seta on the outer margin, is strongly spined, and has a bunch of a few coarse hairs on the inner distal margin. The prothoracic setæ of the ventral side are in the order of 1–1–4–1–1–4–1–1. The relatively short truncate anal segment is with a narrow and acute spur at the apex. (Plate X, Figs. XXIV and XXVII.) The scales of pecten are commonly with two or three well-developed spines. The species is from New York.

Species B Larva is similar to that of *D. cornuta* in arrangement of setæ and in most of its characters. However, it differs in a few well-marked characters. The mandibular teeth are similar to those of species A. (Plate X, Fig. XIX.) Like this species it also has a truncate anal segment with a relatively long point. (Plate X, Fig. XXVI.) But it may be readily separated from this species by the markedly greater length of this segment, which is from one and a fourth to one and a third times as long as the anal segment of larva of species A. It may also be distinguished by the fact that the apical spur of this segment is longer and broader at its base than it is in species A. The species is from New York.

Species E Larva is similar to *D. cornuta* Joh. in general arrangement of setæ except that the ventral setæ of the prothorax are in the order 1–1–2–1–1–2–1–1. A fuscous area is cephaloventrad of the margin of the eye. The species is from California.

To Group II belong *Dixa modesta* Joh. and Species C, D. and F. They are briefly characterized below.

Dixa modesta Larva has short ventral prothoracic setæ in order 1–1–4–1–1–4–1–1. Coronæ are present on the dorsal surfaces of the abdominal segments two to seven inclusive. (Plate X, Fig. XXXIV.) The antennal seta is distinct, but there is no group of antennal hairs. The antennæ are spined, but the palpi are minutely so. The spines of the locomotory plates are well

separated from each other and are weak. The pecten consists of simple strong spines. The pre-spiracular setæ are not palmate, but more like those figured in Plate X, Fig. V. The distal ends of the lateral plates are heavily infuscated and have a very faint indication of a spur or tooth at the apex. The caudal segment is very finely pubescent and unless greatly magnified seems bare. The distal end of the caudal segment does not extend beyond the apex of the lateral plates. (Plate X, Fig. II.) The species is from New York.

Species C Larva. This is similar to *D. modesta.* The palpi and the antennæ are weakly spined. The spiracles are as those figured on Plate X, Fig. XXX. No indication of spurs are at the apices of the lateral plates. The distal end of the anal segment extends slightly beyond the apices of the lateral plates. (Plate X, Figs. XXXVI, XXXVII, and XXXVII′.) The species is from New York.

Species D Larva has a triangular infuscated area at the lateral base of the head. (Plate X, Fig. XVII.) The antennæ and the palpi are fuscous. No strong terminal spine is at the inner end of the pecten, which is composed of deeply fuscous simple spines. Coronæ are present. The prespiracular setæ are as in *D. modesta.* The setæ of the caudal segment are arranged in three pairs, each differing greatly in length from the other two. (Plate X, Figs. XXXI and XXXII.) A specimen from California was studied.

Species F Larva has a wavy chitinized band at the lateral base of the head capsule, which broadens from the dorsal to the ventral surface. (Plate X, Fig. XV.) This larva is similar to that of *D. modesta* but has a caudal segment extending somewhat beyond the apices of the lateral plates and is without even the slightest indication of a tooth at the apex of the lateral plate. The tergum of the tenth segment has a triangular dark chitinized area between the bases of the lateral plates, and the basal margins of the lateral plates are infuscated. The spines of the locomotory plates differ from those of *D. modesta* in being closer together. The third pair of plates is not well developed and is fitted with short spines. Two specimens from New York were studied.

KEY TO LARVÆ OF TEN SPECIES

A. Coronæ on abdominal segments, 2–7; setæ of prothorax and caudal region greatly reduced in length; apex of lateral plates without spur or tooth.

B. Caudal segment not extending past the apices of the lateral plates; a slight indication of an apical spur or tooth at apex of lateral plate ..... *modesta*

BB. Caudal segment extending past the apices of the lateral plates; not even an indication of a tooth or spur at apices of lateral plates.

C. Lateral basal infuscated area at the base of the head in the form of a band slightly widened at center. (Plate X, Fig. XVI.) Species *C*

CC. Lateral basal infuscated area in form of a triangle. (Plate X, Fig. XVII.) ..... Species *D*

CCC. Lateral basal infuscated area of head in the form of a wavy band, broadening from the dorsal to the ventral surface of head capsule. (Plate X, Fig. XV.) ..... Species *F*

AA. No coronæ on abdominal segments; setæ of prothoracic and caudal regions well developed; apical spur or tooth at apex of each lateral plate.

B. Ventral prothoracic setæ in the order 1–1–4–1–1–4–1–1.

C. Caudal segment not truncate but gradually rounding to the point where the caudal spine attaches; the basal portion of mandible does not have a prominent second tooth; common type of pecten scale triradiate ..... *cornuta*

CC. Caudal segment truncate and coming to point abruptly in the apical spine; basal portion of mandible with a prominent second tooth; common type of pecten scale may or may not be triradiate.

D. Caudal segment short, with apical spine narrow and acute. (Plate X, Figs. XXIV and XXVII.) ..... Species *A*

DD. Caudal segment long, with apical spine broader and less acute. (Plate X, Figs. XXIII and XXVI.) ..... Species *B*

BB. Ventral prothoracic setæ not in order 1–1–4–1–1–4–1–1.

C. Heavy fuscous crescent cephalo-ventrad of the eye: ventral prothoracic setæ of the order 1–1–2–1–1–2–1–1 ..... Species *E*

CC. Fuscous crescent lacking; order of ventral prothoracic setæ 1–1–1–4–1–1–4–1–1–1.

D. Common type of pecten scale with two strong spines and a few smaller; teeth of chitinized area of mandible are separated by relatively wide gap; second tooth prominent. (Plate X, Figs. IX and XXI.) ..... *aliciæ*

DD. Common type of pecten scale, eight- or nine-spined; an independently developed seta not only on ventral surface of

eleventh abdominal segment but also on eighth, ninth, and tenth. (*D. cornuta* has this only on the eleventh. Plate IX, Fig. II.) ..... *fusca*

For species C and D use has been made of color characters only. Inasmuch as the specimens of these species were not in good condition, other characters could not be found. However, the fuscous band, which has been used to separate the species, persisted in all preserved specimens examined. Inasmuch as it occurs here in a markedly different type, it was thought to be a specific character. The setæ of the caudal segment of each of these specimens were broken off, and because of lack of knowledge of their character the writer was unable to use the caudal setæ of species F as a distinguishing character of that species by which it could be separated from *Dixa modesta* Joh., as was the case with Species D. (Compare Plate X, Fig. II with Plate X, Fig. XXXII.)

SUMMARY

(1) The following structures of the Dixa larvæ furnish taxonomic characters: mandibular teeth; antennal spines, hairs, and setæ; infuscated areas of the occipital region; the order of long ventral prothoracic setæ; length of setæ of caudal region; presence or absence of supposedly independently derived setæ upon the ventral surfaces of the fifth, sixth, and seventh abdominal segments; prespiracular setæ; length of spines of locomotory plates and the distance between them; the form of the spiracles and the spiracular plates; spurs at distal ends of the lateral plates; chitinous base from which the ventral setæ of the tenth abdominal segment arise; the caudal segment, e.g., its length, shape, amount of pubescence, length of setæ, its extent beyond tips of lateral plates, and shape of spine-like structure at its distal end; types of scales in pecten; and the presence or absence of coronæ upon the dorsal surfaces of the second to the seventh abdominal segments, inclusive.

(2) The larvæ studied are separable into two groups upon the basis of twelve rather definitely correlated characters. The species within each of these groups are separable by a much smaller number of characters than are these groups.

EXPLANATION OF PLATES IX AND X

Plate IX, Fig. I, illustrates a dorsal view of the larva of *Dixa cornuta* Joh. Only the setæ are labeled. Homologues of the different segments are labeled with the same letter. For example, *a* represents the groups of three small dorsal setæ, on each side of the mid-dorsal line; *b*, the dorso-lateral pair. In case one seta of the dorso-lateral pair is lost the remaining seta is labelled *b – 1*. The letters *f*, *g*, and *h* represent setæ of the head to which reference has been made in the body of this paper. The remaining setæ of the head and those of the abdomen caudad of the eighth abdominal segment are labeled elsewhere.

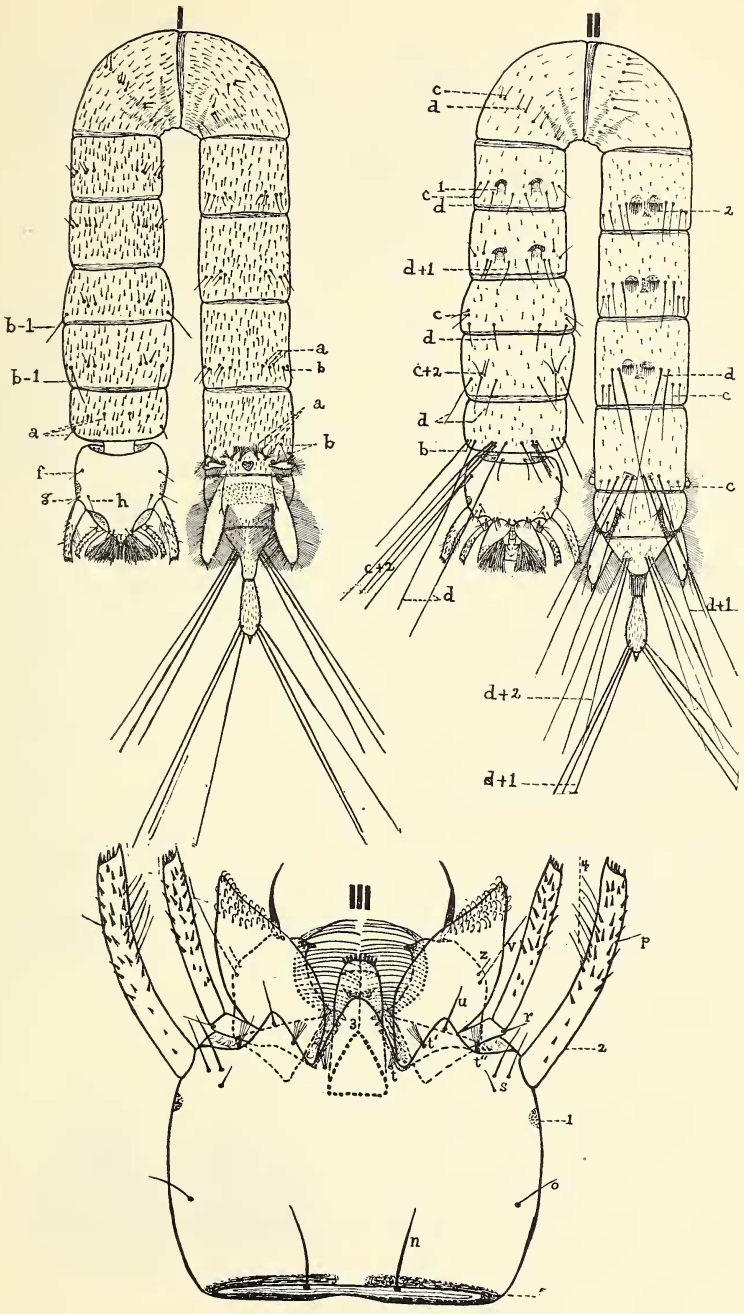
Plate IX, Fig. II, illustrates the ventral view of this larva. The caudal setæ are not figured at full length. The same system for the labeling of homologues of the various segments has been used as in the preceding plate. In the instance that a group of setæ apparently has members which have arisen independently, as in group *c* of the mesothoracic segment, the group is indicated by its usual letter followed by the plus sign and a number representing the setæ which have arisen independently. The letter *b*, perhaps, represents the dorso-lateral group which on the prothorax has moved ventrad; *c*, ventro-lateral pairs; and *d*, ventral pairs to each side of the mid-ventral line. The figure *1* represents one of the four prolegs (two pairs) and *2*, one of the locomotory plates of spines. Setæ and structures of this aspect of the head and of the abdomen caudad of the eighth abdominal segment are indicated elsewhere.

Plate IX, Fig. III, represents the ventral view of the head of this larva with the labrum and mouth-brushes, which would project from beneath the cephalic end, removed. The dotted lines represent structures which lie underneath other structures. A study of Figs. I and IV of Plate X will be of assistance in the interpretation of this figure. As in preceding figures the letters indicate setæ, and these are referred to in the body of the paper. The structures not labeled here are labeled in the figures of the mouth parts on Plate X. Of the other structures 1 represents the eye; 2, an antenna; 3, the "hypopharynx," which runs cephalad and curves dorsad, fitted with rake-teeth-like spines on the cephalic margin of its distal end; 4, bunch of antennal hairs; 5, deeply infuscated area at the base of the head capsule of which a diagram of the lateral view is given in Fig. XVI of Plate X.

Plate X contains figures of some structures of *Dixa cornuta* in greater detail than Plate IX gives them, and there also are many figures, in this plate of structures, which are of taxonomic importance. Fig. I represents the maxilla of *D. cornuta* larva; 1, the palpus; 2, recurved hairs at the apex; and 3, straight hairs at inner basal angle. Fig. II represents the ninth, tenth, and eleventh abdominal segments of *D. modesta* larva (line of segmentation between the tenth and eleventh segments is not figured). 1, illustrates a small seta cephalad of the pecten; 2, a slightly pointed condition of the heavily infuscated apex of the lateral plate; 3, inner spine of

pecten; 4, anal segment; 5, lateral plate; 6, guards of the gill chamber; 7, anal setæ; 8, caudal spur; d + 1, setæ homologues to the setæ d + 1 of the tenth abdominal segment of the larva of *D. cornuta*. Fig. III represents the caudal end of the tergum of the tenth abdominal segment as seen from the ventral aspect with the sternum removed. 1 illustrates the gill-chamber guards. This drawing is from the larva of *D. fusca*. For relationship of these structures to retracted anal gills observe Fig. VI. Fig. IV represents the dorsal view of the mandible of *D. cornuta* larva; 1, is the more strongly chitinized portion of the mandible; 2, the apical spine or claw; 3, the mandibular row of cilia; and *z* and *v* are setæ on the outer margin, the smaller slightly dorsad and the larger slightly ventrad. Fig. V is a group of prespiracular setæ as found in larva of species D. Fig. VI is the ventral aspect of the tenth abdominal segment of the larva of *D. cornuta* (long setæ not shown at full length); 1, retractile anal gills, four in number. Dorsad of the gills are the guards to the gill chamber for which a constant number was not determined. (See Fig. III.) Fig. VII is the common type of pecten spine found in *D. modesta* larva; Fig. VIII, the inner pecten spine of the same species; Fig. IX, the most common type of pecten spine of *D. aliceæ* larva; Fig. X, the common type of pecten spine found in *D. cornuta* larva; Fig. XI, the common type of pecten spine found in *D. fusca* larva; Fig. XII, the inner pecten spine of *D. aliceæ* larva; Fig. XIII, the inner pecten spine of *D. cornuta* larva; Fig. XIV, inner pecten spine of *D. fusca* larva. Fig. XV is a diagram of infuscation at base of head capsule of larva of Species F, as seen laterally; Fig. XVI, diagram of the corresponding area and aspect in *D. cornuta* larva; Fig. XVII, diagram of same area and aspect for larva of Species D. Fig. XVIII represents a palmate prespiracular seta of larva of *D. cornuta*. Fig. XIX is the ventral aspect of the mandible of Species A larva; Fig. XX, ventral aspect of mandible of *D. cornuta* larva; Fig. XXI, ventral aspect of mandible of *D. aliceæ* larva. (Setæ along outer surface not figured in these mandibles.) Fig. XXII illustrates the densely plumose condition of the cilia of the lateral plates of *D. cornuta* larva. Fig. XXIII is an enlarged outline of the dorsal aspect of the extreme tip of the caudal segment of Species B larva; Fig. XXIV, same for larva of Species A; Fig. XXV, same for larva of *D. cornuta*. Fig. XXVI is the anal segment of Species B larva (dorsal); Fig. XXVII, same for Species A larva; Fig. XXVIII, same for *D. cornuta* larva. Fig. XXIX represents the spiracular plate and spiracle of *D. cornuta* larva; 1, a chitinized line; 2, cilia; and 3, apparently a closing device of the spiracle. Fig. XXX represents the type of spiracular plate in *D. modesta* larva. Fig. XXXI represents the lateral view of a portion of the caudal segment of larva of Species D; Fig. XXXII, the ventral aspect of the same structure. Fig. XXXIII represents the sparsely plumose condition of the caudal setæ of the larva of *D. fusca*. Fig. XXXIV illustrates the corona of hair on the tergum of the third abdominal segment of Species C larva. Fig. XXXV is

an outline of the ventral aspect of abdominal segments, six, seven, and eight, as in the larva of Species D; 1 represents a tubercular papilla caudad of the last pair of plates of locomotory spines, and 2, a long raised ridge across the caudal portion of the sixth segment. It should be noticed that the spines of the seventh segment are not well developed and also that the setae *d* of the eighth segment do not have extra setae with them as in *D. cornuta* larva. Fig. XXXVI is the caudal region of larva of Species C (ventral); Fig. XXXVII, the preceding in dorsal view; Fig. XXXVII′, portion broken from the anal segment of the preceding (aspect not determined). Fig. XXXVIII represents the antenna of *D. cornuta* larva; Fig. XXXIX, the antenna of *D. aliciæ* larva. Fig. XL represents the cephalic portion of the dorsal prolongation of the head of *D. cornuta* larva. Of the structures shown, 1 illustrates the mouth-brush; 2, the labrum; *i*, *j*, and *k*, setæ of the normal type; *l*, a clavate seta; and *m*, a large, long seta, truncate at the distal end. Fig. XLI represents a lateral view of the tenth abdominal segment of the larva of Species D.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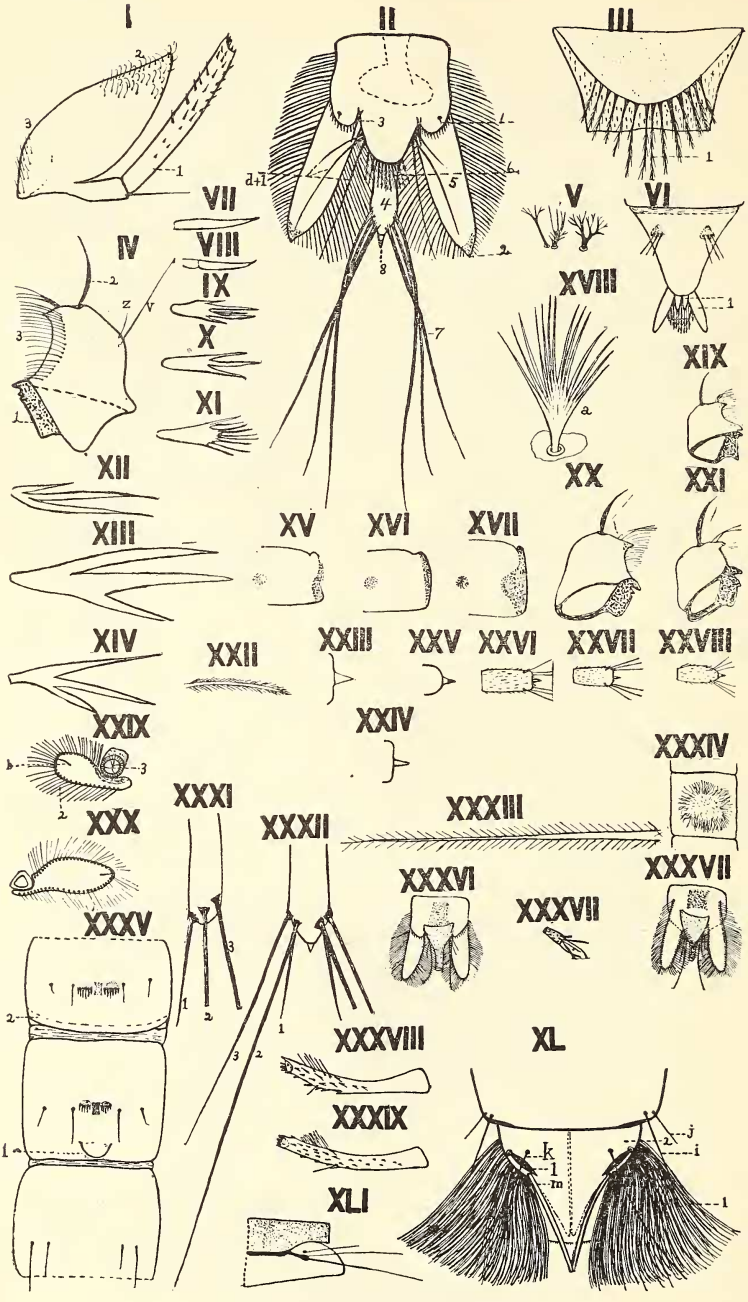
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